Resume of the proposed research topic on:

Design and Development of IoT based Precision Agriculture Systems using Artificial Intelligence

by

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Abstract

The Internet of Things (IoT) and Artificial Intelligence (AI) are promising technologies that offers cost-effective and dependable solutions for modernizing a variety of domains. These technologies have changed the agriculture industry in terms of both quality and quantity.The rapid emergence of the Internet-of-Things (IoT) and Artificial Intelligence (AI) based technologies redesigned almost every industry including - precision agriculture which moved the industry from statistical to quantitative approaches. Such revolutionary changes are shaking the existing agriculture methods and creating new opportunities along a range of challenges. IoT-based solutions are being developed to maintain and monitor agricultural farms automatically and with minimal human intervention. IoT solutions for precision agriculture allow for real-time monitoring to collect valuable data that can analyze and predict such variety of data types in large volumes for the purpose of decision support & can have a significant impact on operational efficiency, this research proposed **Design and Development of IoT based Precision Agriculture Systems using Artificial Intelligence**. With the advancement of technology, this decade has seen a change from traditional to sophisticated approaches. The combination of species hybridization and real-time farm monitoring cleared the path for resource optimization. Scientists, research institutions, academics and almost all nations across the world are moving towards the practice and execution of collective activities to investigate the skyline of this field for serving humanity to meet the ever increasing need of fiber & food.
Furthermore, with the recent surge in Artificial Intelligence, farmers will be able to deploy autonomous agricultural machinery and make better future forecasts based on current and past conditions, reducing crop diseases and pest infestation. Incorporating

IoT with artificial intelligence (AI) can provide enough scope to predict process and evaluate situations in real time, as well as optimize activities. Artificial intelligence is used in soil and irrigation management, weather forecasting, plant development, disease prediction etc. This will assist enhance agricultural product yields and farmers will be able to make decisions based on the data provided for future planning. The major goal of this technology is to boost agricultural yields and make sound farming decisions in the future. This efficient technology may deliver predictive analytics on data in a very simple and quick manner, depending on the respondent history of a particular yield.

1. Introduction

As the world's population continues to increase so does the demand for fiber & food, placing pressure on the world's farmers to improve efficiency and cut costs while boosting crop yields. According to the Food and Agriculture Organization of the United Nations, the world population will reach over 9 billion by 2050. Rapid population growth, shrinking farmland, natural resources that are decreasing, erratic climate changes and shifting market demands are pushing the agricultural production system into a new paradigm. The new agricultural system must become more productive in output, efficient in operation, resilient to climate change and sustainable for future generations. Internet of Things (IoT) and Artificial Intelligence (AI) holds promise in addressing the challenges of this new paradigm. IoT works much better when AI is integrated, When AI is added to the IoT logic, and the quality of the outcome will draw the attention of not only users but also the researchers to develop more sophisticated solutions [16].

A significant amount of work has been done regarding IoT technology in agricultural area to develop smart farming solutions. IoT has brought a great revolution in agriculture environment by examining multiple complications and challenges in farming. Now a days, with the advancement of technology it has been expected that by using IoT agriculturalists and technologists are finding out the solution of those problems which farmer are facing such as shortages of water, cost management and productivity issues etc.,[2]. State-of the-art IoT technologies have detected all these issues and provide solutions to increase productivity while lowering the cost. Efforts made on wireless sensor networks enable us to collect data from sensing devices and send it to the main servers. Data collected through sensors gives information about different environmental condition to monitor the whole system properly [11]. Monitoring the environmental conditions or crop productivity is not only the factor for the evaluation of crop but there are many other factors which effect the crops productivity, e.g. field management system, soil and crop monitoring, movement of an unwanted object, attacks of wild animals and thefts etc. Moreover, IoT provides a well-organized scheduling of restricted resources which makes sure that the best use of IoT enhances the productivity [4].

The result is a more efficient system that promotes sustainable growth while cutting costs. With precision farming, farmers generate data via sensors and analyze and predict the information to evaluate current practices and make improvements for greater efficiency and effectiveness [10]. There are a variety of smart farming applications including crop observation, vehicle tracking, irrigation management, greenhouse management, livestock management and storage monitoring & distribution

monitoring etc. All this will increase the productivity and efficiency of the crops that will in the end lead to higher production and revenue. Decision support helps the farmer make better decisions that prevent mistakes and increase efficiency[12]. Until now, the implementation of automated monitoring and control systems has been limited by the poor coverage of cellular networks in many highly productive but sparsely populated rural areas. Now a day's technologies like IEEE 802.11 WIFI, LoRaWAN, WIMAX, RFID, ZIGBEE, Bluetooth [8] [6]. IIoT now enables detection, monitoring and control over very long distance of a wide variety of key agricultural data: soil temperature and moisture; climate conditions, rainfall and water quality; airborne pollution; crop growth, pest and crop disease; livestock position, condition and feed levels; irrigation equipment; fire, theft and flood detection. These technologies having long-range, low-power wireless qualities which enables the use of low-cost sensors to send data from the farm to the Cloud where it can be analyzed to improve operations. The IoT invention improves agriculturalists' and technologists current way of life by coordinating all of the objects to a high level in the broad bearings. Smart farming and global nourishment generation will be aided by web innovations, interpersonal organizations, verified incorporated databases and data accessibility on demand [5]. The goal of Smart Farming is to improve the quality and quantity of rural generation by adopting innovative techniques to make farmers more knowledgeable and progressively associated. These challenges will be addressed by new inventive IoT applications, which will aid in increasing the quality, sum, sensibility and cost feasibility of cultivating creation.

Artificial intelligence (AI) can help farmers get more from the land while using resources more sustainably. This technology refers to the large volume of data coming from sensors, IoT, GPS, aerial imagery, etc. IoT is a system of embedded technologies consisting of wired and wireless communications, sensors and actuators that are capable of acquiring and transferring data to the internet. Today's Farms, with the help of IoT, Unmanned Aerial Vehicle (UAV) and other emerging technologies is producing millions of data points on the ground daily. With the help of AI, farmers can now analyze weather conditions, temperature, water usage, energy usage and soil conditions collected from their farm to better inform their decisions. Unlike before, farmers additionally now can use captured sensor data in predicting yield and making them better equipped to natural disaster and climate conditions through intelligent data processing techniques like machine learning. IoT, combined with AI, is emerging as part of the solutions toward improved agricultural productivity and efficiency. From detecting plant diseases to monitoring harvest time, AI's application in agri-technology is enormous and yet to be tapped. AI in agriculture application is emerging in three areas: robotics, soil and crop monitoring and predictive analytics [14].

2. Review of Literature and Development in the subject

Sameer Qazi, Bilal A. Khawaja, and Qazi Umar Farooq, discussed the importance of smart agriculture practices with the growing gaps in global food demand versus current food generation, the growing shortage of arable land for agriculture, stricter regulations by International organizations on the use of toxic pesticides/herbicides and global shortage of water resources for irrigation purpose. Author then discussed in detail the current hardware building blocks of the smart agriculture system, which is primarily based upon a large number of IoT nodes deployed in the field with suitable sensors to monitor the current situations of crops. The monitored parameters are transmitted wirelessly through various available technologies for the farmer to take remedial

actions manually or automatically through pre-programmed instructions to actuators. Authors discuss the automated control algorithms and strategies along with their advantages and limitations for one particularly important application, smart irrigation, in view of recently depleting water resources [1].

Vippon Preet Kourand Sakshi Arora states that the agriculture sector along with its challenges and economic importance is presented. The domain of IoT along with the communication technologies and goals, protocols, architectures are studied and put forward. The various IoT OS, their specifications and features with respect to agriculture are discussed. An analytic study of various articles in the field of agriculture is presented, highlighting their most focused sections and gaps or areas not addressed. The sensors based on their field of application are also discussed. A systematic review of different articles focusing especially on crop monitoring, irrigation, disease detection, and farm management is offered. From the studies, certain issues are put forward that demand research and experimentation in the future. Various existing public and private sector platforms or start-ups which work for precision farming are also presented and discussed with their specifications and applications. Making precision farming a base, a layout of an IoT based architecture is proposed. The communication technologies and the hardware platforms of IoT are also discussed. The applications of IoT in agriculture are also discussed. The issues, challenges and future research directions are highlighted. As a whole, the in-depth description of various aspects of IoT for agriculture has been discussed and how these studies should be catered in a way to create efficient and smart agricultural scenarios [3].

Dmitrii Shadrin, Alexander Menshchikov, Andrey Somov, Gerhild Bornemann, Jens Hauslage and Maxim Fedorov have presented a generic low-power embedded platform equipped with the AI on board for assessing and predicting the plant growth dynamics. Performance evaluation of the proposed solution has demonstrated that the developed AI architecture based on an RNN called the LSTM is characterized by reasonable precision for horizon of prediction. The proposed solution can be used as an autonomous tool for the continuous plant growth dynamics monitoring for up to 180 days. Together with an actuating capability, the proposed approach is promising for guaranteeing an easy-to-deploy, generic and robust optimization tool for the precision agriculture [13].

Yemeserach Mekonnen, Srikanth Namuduri, Lamar Burton, Arif Sarwat and Shekhar Bhansali, Yield prediction is a vital feature of precision agriculture that utilizes farm land and weather data to help farmers increase crop production. Farm land data, which can be manipulated by man, can include land usage and preparation depth of till, soil texture, soil structure, organic matter present, the amount of fertilizers present and consumed, efficiency of water usage based on the type of irrigation scheme, crop rotation pattern, method for pest and weed control, total yield produced. Environmental weather data can include temperature, rainfall, solar radiation, wind speed; presence of pests, weeds and biodiversity. The use of advanced sensor technology allows this data to be autonomously collected in a non-destructive manner. This acquired data is then employed with ML to provide actionable insight, there by selecting the best decision management systems for yield prediction [14].

Muhammad Shoaib Farooq, Shamyla Riaz , Adnan Abid , Tariq Umer and Yousaf Bin Zikria has presented a systematic literature review that presents a discussion on

selective high-quality research articles published in the domain of IoT-based agriculture. Thereafter, an analysis of different IoT agriculture applications, sensors/devices and communication protocols has been presented. The most promising fact is that this area of research is being patronized by the governments of various countries and many countries have their IoT agriculture policies. Apart from this, all the major components of IoT-based agriculture have been contextualized in a framework. Lastly, the promising future directions have been discussed for the researchers working in the domain of IoT-based agriculture [15].

3. Objective of Research/ Proposed Hypothesis

The precision agriculture using IoT and related work focusing on the current research aimed at improving and enhancing the crop performance and environmental quality. It was decided to design and develop a low cost system to achieve following objectives:

1. The proposed system designed to provide a solution to increase productivity while lowering the cost in open & enclosed agricultural systems.

2. To proposed prediction based decision making system reduce the risk of loss and increase the profit of farmers, it will also provide necessary information about planning of crops, fertilization & scheduling of various agriculture parameters.

3. The proposed systems that can predict future conditions, help farmers make proactive decisions and enhance marketing of farm products.

4. To conduct research on the economic and environmental feasibility of the precision agriculture technology that would promote this technology to be accepted and adopted by farmers and environmentalists.

5. The proposed system will predict the disease on the crop & provides the solutions based upon crop condition.

4. Methodology to be adopted

The proposed research provides smart agriculture solutions/techniques using IoT & Artificial intelligence.

- **Various agriculture parameters measurement, monitoring and control**
  In the field various sensors deployed for measurement of soil moisture, Temperature, Humidity, Plant Diseases, Real-Time Pest Detection, Weed Detection, Crop Management etc. and data collected from theses sensors can be send to decision support system.

- **Weather parameters**
  Weather parameters also measured based on scheduling of various agriculture activities as well as predicting & forecasting of weather parameters for precision agriculture.

- **Data Collection & Analysis from various sensors**
  Collection of data can be done by implementing various sensors in the field to measure the necessary parameters like soil temperature, humidity, soil moisture, crop quality, plant growth and many more. Then that data can be analyzed to take a corrective action.

- **Predictive Analytics**
  Remote sensing has been used to forecast the expected crop production and yield over a given area. It could also help to determine how much of the crop will be harvested under specific conditions. Advances in AI-based data analytics help farmers protect natural resources like land, air, water, energy and reduce the amount of inputs needed for successful harvests like seeds, water, pesticides etc.

- **Solar based systems**
  Solar based systems for all the equipments like sensors, actuators, signal conditioning & pump.

5. Importance of study/Society application

- **International Status**
  By 2025, the global population will reach at 8 billion people, and by 2050, it will be at 9.6 billion. The interpretation of this data shows that to tackle this population growth, an estimated increase of 70% in food production must be achieved worldwide [17].

- **National Status**
  In India, 53% of the population is dependent on the agriculture sector for employment and 61.5 % of the Indian population is primarily dependent on the agriculture sector for its livelihood. At present, the demand is more than the supply generated& to maintain the demand-supply curve, there will be enormous stress on the agricultural sector. Global warming and changing climatic conditions are also important factors to be taken into consideration. From the past decades, due to the increase in demand and pressure on the overall structure of the field, this area is witnessing the slow but progressive shift from traditional approaches to the most advanced technology driven methods.

- **Significance of the Study**
  The research study could provide the information on the issues of measurement of various parameters, monitoring, controlling and analysis of real time field data to create the database for better decision support to farmers. This study would be beneficial to the Agriculture Department of Government in the country/state as this study enhance the knowledge of the officers and farmers about the possible issues on precision agriculture technology. This study would be beneficial to the farmers as it provides the necessary information of the various parameters to be controlled and monitored & future decisions and predictions. To the future researchers, this study can provide baseline information of the recent technology used for agriculture applications.

6. Proposed work plan/Formulation and structure of study

Activities First Year	Month	1		2		3		4		5		6		7		8		9		10		11		12	
	Days	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Compilation of Problem statement	15																								
Research foundation setup	60																								
Up gradation of computing facilities	30																								
Research work planning	30																								
Working on research work	90																								
Review pertinent literature	270																								
Develop a scope statement	30																								
Research Equipment Study and selection of technology	120																								
Selection of measurements and research equipment	135																								
Action and evaluation of experiment design experimental setup	75																								

Activities Second Year	Month	1		2		3		4		5		6		7		8		9		10		11		12	
	Days	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Field Visits getting an acquaintance	30																								
Visit Libraries	45																								
Attend National conference, symposia and workshops	45																								
Organize 1 week IOT workshop	30																								

Synthesize, Analyze information sources	60																							
Integrate prior knowledge	30																							
Implementation and integration of system	60																							
Development of software and testing	120																							
research result publications	45																							

Activities Third Year	**Month**	**1**		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**		**10**		**11**		**12**	
	Days	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
System collaboration testing with existing systems	75																								
Deployment and testing results	120																								
Publications and findings	45																								
Results, outcome and performance	60																								
Field Testing	60																								
Demonstration of project work	30																								
Objective analysis check	30																								
Preparation of complete report and submission to university	30																								

7. References

[1] Sameer Qazi, Bilal A. Khawaja and Qazi Umar Farooq, "IoT-Equipped and AI-Enabled Next Generation Smart Agriculture: A Critical Review, Current Challenges and Future Trends", *IEEE Access,* VOLUME 10, 2022, Page No. 21219-21235, February 17, 2022, Doi*10.1109/ACCESS.2022.3152544.*

[2] Muhammad Shoaib Farooq, Shamyla Riaz, Adnan Abid, Kamran Abid and Muhammad Azhar Naeem, "A Survey on the role of IoT in agriculture forthe implementation of

smart farming", Special Section on New Technologies for Smart Farming 4.0: Research Challenges and Opportunities, *IEEE Access*, Vol. 7, pp. 156237- 156271, 2019.

[3] Vippon Preet Kourand Sakshi Arora, "Recent Developments of the Internet of Thingsin Agriculture: A Survey"*IEEE Access*, Vol. 8, 2020, pp. 129924-129957, 2020.

[4] Mohamed Amine Ferrag, Lei Shu, Xing Yang, Abdelouahid Derhab, and Leandros Maglaras, "Security and Privacy for Green IoT-Based Agriculture: Review, Blockchain Solutions, and Challenges", Special Section on Green Internet of Things, *IEEE Access*, Vol. 8, pp. 32031- 32053, 2020.

[5] Anusha Vangala, Ashok Kumar Das, Neeraj Kumar and Mamoun Alazab, "Smart Secure Sensing for IoT-Based Agriculture: Blockchain Perspective", *IEEE Sensors Journal*, 2020.

[6] G. Vennila, Dr. D. Arivazhagan and Dr. R. Jayavadivel, "An Investigation of IOT Based Smart Agriculture", *International Journal of Scientific & Technology Research,* Vol. 9, Issue 01, pp. 2054-2056,2020.

[7] Ala Al-Fuqaha, Mohsen Guizani, Mehdi Mohammadi, Mohammed Aledhari and Moussa Ayyash, "Internet of Things: A Survey on Enabling Technologies, Protocols and Applications", *IEEE Communications Surveys & Tutorials*, 2015.

[8] Nurzaman Ahmed, Debashis Deand Md. Iftekhar Hussain, "Internet of Things (IoT) for Smart Precision Agriculture and Farming in Rural Areas", *IEEE Internet of Things Journal*, VOL. 5, NO. 6, pp. 4890-4899, December 2018.

[9] Li Li , Maohua Wang , Man Zhang, Minzan Li, Nick Sigrimis and Ahileas Anastasiou, "Application of IoT Technology in Greenhouse Management", *2012 ASABE Annual International Meeting,*2012.

[10] Mustafa Alper Akkasa and Radosveta Sokullub, "An IoT-based greenhouse monitoring system with Micaz motes", International Workshop on IoT, M2M and Healthcare, *Procedia Computer Science, Elsevier*,pp. 603–608, 2017.

[11] Sumarga Kumar, Sah Tyagi, Amrit Mukherjee, Shiva Raj Pokhrel and Kamal Kant Hiran, "An Intelligent and Optimal Resource Allocation Approach in Sensor Networks for Smart Agri-IoT" *IEEE Sensors Journal*, 2020.

[12] Naiqian Zhang, Maohua Wang, Ning Wang: "Precision Agriculture- A World Wide Overview", *Elsevier 2002.*

[13] Dmitrii Shadrin, Alexander Menshchikov, Andrey Somov, Gerhild Bornemann, Jens Hauslage and Maxim Fedorov, "Enabling Precision Agriculture through Embedded Sensing with Artificial Intelligence", *IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT,* VOL. 69, NO. 7, JULY 2020, PP.4103-4113.

[14] Yemeserach Mekonnen, Srikanth Namuduri, Lamar Burton, Arif Sarwat, and Shekhar Bhansali, "Review-Machine Learning Techniques in Wireless Sensor Network Based Precision Agriculture"*Journal of The Electrochemical Society*, 2020 DOI: 10.1149/2.0222003JES.

[15] Muhammad Shoaib Farooq, Shamyla Riaz , Adnan Abid , Tariq Umer and Yousaf Bin Zikria, "Role of IoT Technology in Agriculture: A Systematic Literature Review", *MDPI, Electronics 2020*, 12 February 2020; Doi10.3390/electronics9020319.

[16] Chandrakant Naikodi, Suresh L, "The Today and Future of WSN, AI and IoT", *BPB Publication,* 1st edition 2020.

[17] Abhinav Sharma, Arpit Jain, Prateek Gupta and Vinay Chowdary, "Machine Learning Applications for Precision Agriculture: A Comprehensive Review", *IEEE Access,* 31 Dec, 2021, Doi:10.1109/ACCESS.2020.3048415

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